

TITLE
**LASER SYSTEM FOR
MEASUREMENTS OF THE PROFILE OF OBJECTS**

5 CROSS REFERENCE TO RELATED APPLICATIONS

 This application claims the benefit of U.S. Provisional Patent Application Serial No. 60/457,140 filed March 24, 2003.

BACKGROUND OF THE INVENTION

10 1. Field of the Invention:

 The present invention relates to measuring systems and more particularly to a laser system for measuring the profile of an object such as a container, for example.

 2. Description of the Prior Art:

15 The prior art systems have commonly included measuring the profile of an object utilizing manually operated micrometers. This typically requires a person to make manual measurements about a perimeter of the object, read the micrometer (whether digital or inscribed), and record the measurement data accordingly. A user then manually enters the measurement data into a
20 computer. While such systems achieve the measurement objectives, the systems consumed rather substantial quantities of time and required manual dexterity.

SUMMARY OF THE INVENTION

 It is an object of the present invention to produce a system for
25 measuring the profile of an object which is automatic.

 Another object of the invention is to produce a system for measuring the profile of a plurality of objects wherein the plurality of object to be

measured may be delivered and removed from the system automatically.

Another object of the invention is to produce a system for measuring the profile of an object utilizing a laser micrometer.

Still another object of the invention is to produce a system for
5 measuring the profile of an object and determine the displacement of the top of the object from a given point and the base thereof.

Still another object of the invention is to produce a system for measuring the profile of the threaded finish portion of a container adapted to receive a threaded closure.

10 The above as well as other object of the invention may be achieved by a system for measuring the profile of an object comprising a source creating a beam of electromagnetic energy. An electromagnetic beam receiver spaced from the source processes an output signal proportional to the girth of the object being measured. A platform for providing rotational and vertical
15 movement of the object being measured causes the object to obstruct a portion of the electromagnetic beam generated by the source. A processor for processing the output signal from the electromagnetic beam receiver forms a composite profile of the object measured.

20 BRIEF DESCRIPTION OF THE DRAWINGS

Other objects and advantages of the invention will become manifest to those skilled in the art from reading the following detailed description of an embodiment of the invention when considered in the light of the accompanying drawings, in which:

25 Fig. 1 is a block diagram illustrating a laser measurement system of the present invention.

Fig. 2 is a schematic front view of a laser measurement system according to a first embodiment of the present invention; and

Fig. 3 is a schematic top view of a portion of the laser measurement system illustrated in Fig. 2.

5 Fig. 4 is a schematic front view of a laser measurement system profiling an object.

Fig. 5 is a schematic top view of a portion of the laser measurement system illustrated in Fig. 4.

10 Fig. 6 is a schematic side view of a vertical and rotational motion unit according to the present invention.

Fig. 7 is a perspective view of a carousel unit according to the present invention.

Fig. 8 is a flowchart illustrating a method for profiling a plurality of objects using a laser measurement system.

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DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawings, there is illustrated a measuring system for measuring the outer profile of an object. It has been surprisingly determined that the system is particularly useful for providing a quick and
20 simple way of obtaining the profile parameters of PET bottles, filled or empty.

The system illustrated in Fig. 1 includes a block diagram of a laser measurement system. The laser measurement system includes a measuring device **10** which is a Takikawa Laser Micrometer (Model LDM-305H), purchased through DAS Distribution, Inc. (www.dasdistribution.com). The
25 measuring device **10** includes a laser transmitter unit **18** and a laser receiving unit **20**. The laser transmitter unit **18** (i.e., source) transmits a primary beam

of electromagnetic energy in the direction of the laser receiving unit 20 for profiling an object disposed within the primary electromagnetic beam. A processor 21 within the measuring device 10 processes measurement data received from the laser receiving device 20 and transmits the measurement data to a computer 16 for storage in a file. The measuring device 10 is mechanically coupled to a platform stand 26. The platform stand 26 supports the measuring device 10. A motion unit 14 is mechanically coupled to the platform stand 26 and provides vertical and rotational displacement of an object. The motion unit 14 includes a rotational platform 12 for supporting and rotating the object and a vertical drive device 15 for upwardly or downwardly moving the object positioned on a rotational platform 12. The rotational platform 12 is rotationally coupled outward from the vertical drive device 15 for supporting and rotating the object within the primary electromagnetic beam about a vertical axis. The rotational platform 12 is rotatable 360° for profiling the entire circumference of the object in a respective plane.

Fig. 2 and Fig. 3 illustrate a schematic front view and top view of the laser measurement system, respectively. The platform stand 26 is affixed to a bottom surface of the measuring device 10 for supporting the measuring device 10. The measuring device 10 includes the transmitter unit 18 disposed on a first side of the measuring device 10 and a receiving unit 20 disposed on a second side of the measuring device 10. The transmitter unit 18 and the receiving unit 20 are spaced a predetermined distance apart from one another. The vertical drive unit 15 and the rotational platform 12 are disposed therebetween. The transmitting unit 18 transmits a 7" wide electromagnetic laser beam 22 (i.e., primary) in the direction of the receiving unit 20 for

profiling the object. The electromagnetic laser beam 22 is a class II laser light source from a visible red semiconductor laser (670nm) with a 1 mW maximum output. In alternative embodiments, other laser light sources may be utilized.

5 The measuring device 10 includes the processor 21 (shown in Fig. 1) for maintaining measurement data polled from a profiled object. The processor 21 communicates with the computer 16 via a communication line 24 (e.g., RS232 cable) for transmitting measurement data between the processor 21 and the computer 16. Alternatively, other types communication
10 lines may be used such as a USB cable or firewire.

Fig. 4 illustrates the object disposed within the laser measurement system for profiling. A plastic container 28 is disposed on the rotational platform 12. An advantage of the present invention is that the laser measurement system may profile the plastic container 28 whether filled,
15 empty, or partially filled with a substance. The plastic container 28 may be measured prior to and after the substance has been added. This allows for statistical quality control and inspection of the plastic container 28. After the plastic container 28 is positioned on the rotational platform 12, depending on its initial position, the vertical drive unit 15 is indexed upward or downward
20 to an initial measurement position. Software is provided for transmitting control signals to the motion unit 14 for controlling the motion of the vertical drive device 15. The software also provides control signals for controlling the rotary motion of the rotational platform 12. As a result, the software raises, lowers, and rotates the plastic container 28 to align a respective plane of the
25 plastic container 28 with the electromagnetic laser beam 22.

The vertical drive device 15 utilizes a linear screw drive to produce the

vertical displacement. The linear screw drive is rotated either clockwise or counterclockwise under software control to move the rotational platform 12 upward or downward.

When the plastic container 28 is moved between the transmitter unit 18
5 and the receiving unit 20, the electromagnetic laser beam 22 is obstructed thereby reducing it to two smaller beams (i.e., secondary beams). That is, the electromagnetic laser beam 22 will be split into two smaller laser beams as seen by the receiving unit 20.

Fig. 5 illustrates the splitting of the electromagnetic laser beam 22. A
10 dark area 30 is shown generally indicating a region where no laser radiation is received by the receiving unit 20 as a result of the plastic container 28 blocking the electromagnetic laser beam 22. A first smaller beam 32 includes a portion of the electromagnetic laser beam received by the receiving unit 20 that is unobstructed by the plastic container 28. The width of the first smaller
15 beam 32 is dependent on the obstruction of the plastic container 28 and the passage of the portion of the unobstructed electromagnetic beam from a first exterior surface of the plastic container 28 to a first adjacent edge of the electromagnetic laser beam 22. Likewise, a second smaller beam 34 received by the laser receiving unit 20 is a portion of the electromagnetic laser beam
20 that is unobstructed by the plastic container 28. The width of the second smaller beam 34 is dependent on the obstruction of the plastic container 28 and the passage of the portion of the unobstructed electromagnetic laser beam from a second exterior surface (i.e., 180° opposite the first exterior surface) to a second adjacent edge of the electromagnetic laser beam 22. The resulting
25 signals are received and measured by the receiving unit 20. These resulting signals include a first smaller beam 32 having a first width, a void of a

darkened area 30, and a second smaller beam 34 having a second width. The profile of a respective plane of the plastic container 28 (i.e., girth) is directly proportional to the void of the darkened area 30. The profile of a respective plane of the plastic container 28 may be determined by directly measuring the void of the darkened area 30. Alternatively, the profile a respective plane of the plastic container 28 may be determined by the difference between the width of the electromagnetic laser beam 22 and the first and second smaller beams 32 and 34 received by the receiving unit 20.

The plastic container 28 may also be rotated by the rotational platform 12 for profiling at least one view within a respective plane. The rotational platform 12 includes a rotational drive device 17 for rotating the plastic container 28 supported by the rotational platform 12, as shown in Fig. 6. In the preferred embodiment, the rotational drive device 17 includes a gear driven mechanism. A motor (such as a stepper motor) may be used to drive the gears of the rotational drive unit. In another embodiment, a belt driven mechanism may be utilized to rotate the rotational platform 12. Position encoders may also be utilized for determining the rotational position of the rotational platform at any given degree of rotation. As a result, the plastic container 28 may be moved vertically to profile any respective plane and rotationally to profile a respective view.

At any point, the software can poll the position of the vertical drive unit 15 and the rotational platform 12 relative to the plane of the electromagnetic laser beam 22 and retrieve a resulting data measurement. By entering minimal initial information to the software program such as heights at which to measure, incremental degrees by which to rotate the object, and a mode in which to scan (see *Bulge/Pinch infra*), an object specific program can

be built in a matter of seconds. After the initial information is entered, the plastic container 28 is placed on the rotational platform 12 and a scan operation is initiated. The measuring device 10 will profile the plastic container 28 given the operating parameters of the initial information entered and transmit the measurement data to a file stored in the computer 16 via the communication line 24. To scan a second plastic container of an identical size and shape, the first plastic container 28 is removed from the rotational platform 12 and the second plastic container is positioned on the rotational platform 12. The scan operation is thereafter initiated. Measurement data retrieved from each plastic container profiled is stored in one or more files in the computer 16.

The motion unit 14 is positioned relative to the measuring device 10 such that an upper bounds of the motion unit 14 places the top support surface of the rotational platform 12 flush with the plane of the electromagnetic laser beam 22. This is considered the zero reference point for all vertical motion measurements with respect to objects of this same form. Any polling by the computer 16 for position and measurement data are relative to the zero reference point.

In addition to measuring an object at a specific height and degree requested by the user, the measuring device 10 can scan a region of the object, search for the maximum (bulge) or minimum (pinch) diameter measurement in that area, and then take measurement data around the object at that location.

This is advantageous to users tracking changes between an unfilled plastic container and a filled plastic container. Such measurements may be utilized for quality or statistical process control (SPC) at critical locations.

Furthermore, an entire exterior surface of a plastic container may be profiled

thereby creating a visual profile of the plastic container as a whole.

The preliminary information entered into the computer 16 can be saved in an object profile. The next time the object (or same formed object) is measured, the saved object profile may be retrieved and utilized for profiling
5 as opposed re-entering the preliminary information manually by the user.

The software further has a built-in calibration feature that will calibrate the vertical motion of the laser measurement system. When an object of a known height is placed onto the rotational platform 12, the height of the object is entered into the software by the user. The software will provide
10 commands to scan for the top of the object. The rotational platform 12 is then moved up the height of the object and re-zero the value for the vertical motion.

The present invention further has the advantage of measuring the perpendicularity of an object (i.e., a bottle). Perpendicularity is important
15 where alignment is critical between the opening of the bottle and a filler adapter of a dispensing unit dispensing a substance into a bottle. Vertical alignment between the opening of the bottle and the filler adapter must be achieved to allow spill-free dispensing from the dispensing unit to the bottle. The object is placed on the rotational platform 12 and centered thereon. The
20 system will then determine the displacement of the top of the object (i.e., center of the bottle opening) to the center of the table, which constitutes the measure of the perpendicularity of the object.

Furthermore, the laser measurement system may be used to measure and verify detailed information in regards to the thread finishing for proper
25 alignment with a mating threaded end cap. The bottle is placed on the rotational platform 12 and scanned at various planes of the threaded portion

for determining significant dimensional information from the finished threads. This is different from the typical measurements generated above because the threads are not in the same plane, but rather the threads spiral downward around the filler neck of the bottle. Measured thread dimensions includes a
5 "T" dimension (i.e., thread crest diameter), an "E" dimension (i.e., thread root diameter), an "A" dimension (i.e., tamper evident bead diameter), and a "Z" dimension (i.e., maximum diameter on support ledge). Furthermore, by knowing the location of a plurality of "T" dimensions, the thread pitch is determined.

10 In the illustrated embodiment, the user has to manually place and remove the objects being measured in the laser measurement system. In an alternative embodiment, an indexing station is provided similar to a carousel system, as shown in Fig. 7. An indexing station shown generally at 36 is disposed above the measuring device 10. The rotational platform 12 is
15 vertically moved to a respective position by the drive unit 15 such that the top surface of the rotational platform 12 is aligned horizontally with a stationary track floor 40 of the indexing station 36. The user would place a plurality of objects 38 on the indexing station 36. A plurality of separator guides 44 separate the plurality of objects 38 from one another. The plurality of
20 separators guides 44 are "V-shaped" so that each of the plurality of objects 38 may be properly retained and moved along the track floor 40 while being indexed. When the scan operation is commenced, the first object is moved along the track floor 40 and displaced onto the aligned top surface of the rotational platform (i.e., loading position) by a first separator guide. The
25 motion unit is then moved downwardly to commence profiling of the first object.

After the measurement laser system has completed profiling and retrieving measurement data from the first object, the vertical drive unit 15 moves the rotational platform 12 upward to the loading position. The indexing station is advanced, so that the first object is displaced off the top surface of the rotational platform and onto the track floor 40 by the first separator guide. A second object is simultaneously moved along the track floor 40 and is displaced onto the top surface of the rotational platform 12 by a second separator guide. The second object is thereafter vertically moved and rotated for retrieving measurement data. The software controls the indexing of indexing station 44 so that each of the plurality of objects 38 are profiled and measurement data retrieved. Measurement data from each profiled object will be stored in a same file for data processing and retrieval. Alternatively measurement data may be stored in a plurality of files.

Fig. 8 illustrates a method for measuring an object using the laser measurement system. In step 50, data is entered into a computer software program containing the preliminary information of the plastic container. Such preliminary information may include height of the object, heights and locations which to measure, incremental degrees by which to rotate the object, scan mode, and the number of objects to profile. If the preliminary information for a respective object has been previously entered and stored, the preliminary information may be directly retrieved from a stored file in the computer's memory. After the preliminary information is manually entered by the user or retrieved from the stored file, a scan operation is initiated in step 51. In step 52, the indexing unit is advanced. A respective separator guide guides a respective plastic container onto the top surface of the rotational platform. Proximity sensors may be positioned in the indexing unit

for determining the presence of a plastic container on the rotational platform to commence profiling. In step 53, optional tooling may be used to center the plastic container on the top surface of the rotational platform, if desired.

In step 54, the zero reference point is established by vertically
5 descending the rotational platform to the position where the bottom plane of the plastic container is inline and obstructing the electromagnetic laser beam. In step 55, the plastic container is vertically moved to at least one vertical position as predetermined from the preliminary information entered into the software program. In step 56, the plastic container is rotated a respective
10 number of degrees for profiling at least one respective view within a respective plane. In step 57, the measurement data of a respective profile is transmitted to the computer via a communication line and stored in a file.

In step 58, the plastic container is returned to the load position. In step 59, a determination is made whether all of the plastic containers have been
15 profiled by the laser measurement system. The software programs keeps track of whether all plastic containers have been profiled based on a number of plastic containers entered as part of the preliminary information for profiling versus the number of times the indexing table is indexed. If the determination is made in step 59 that more plastic containers require profiling, a return is
20 made to step 52 to advance the indexing unit for profiling of the next plastic container. If the determination is made in step 59 that all plastic containers have been profiled, then the scan operation is terminated in step 60.

From the above description, it will be apparent that the described and illustrated system has produced a quick and simple method and apparatus for
25 measuring the outer profile of an object. The system has been found to be particularly useful for measuring PET bottles, empty or filled, as well as

preforms and associated tooling.

In accordance with the provisions of the patent statutes, the present invention has been described in what is considered to represent its preferred embodiment. However, it should be understood that the invention can be
5 practiced otherwise than as specifically illustrated and described without departing from its spirit or scope.